# JEE Main Previous Year Solved Questions on Fluid Mechanics

**Q1: A solid sphere of radius R acquires a terminal velocity $v_1$ when falling (due to gravity) through a viscous fluid having a coefficient of viscosity η. The sphere is broken into 27 identical spheres. If each of these acquires a terminal velocity $v_2$, when falling through the same fluid, the ratio $(v_1/v_2)$ equals**

(a) 9

(b) 1/27

(c) 1/9

(d) 27

**Solution**

$27 \times (4/3)\pi r^3 = (4/3)\pi R^3$

Or $r = R/3$

Terminal velocity, $v \propto r^3$

Therefore, $(v_1/v_2) = (R^2/r^2)$

$v_1/v_2 = [R/(R/3)]^2 = 9$

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**Answer: (a) 9**

**Q2: Spherical balls of radius R are falling in a viscous fluid of viscosity with a velocity v. The retarding viscous force acting on the spherical ball is**

(a) directly proportional to R but inversely proportional to v

(b) directly proportional to both radius R and velocity v

(c) inversely proportional to both radius R and velocity v

(d) inversely proportional to R but directly proportional to velocity v

**Solution**

Retarding viscous force = 6πηRv

obviously option (b) holds goods

**Answer: (b) directly proportional to both radius R and velocity v**

**Q3: A long cylindrical vessel is half-filled with a liquid. When the vessel is rotated about its own vertical axis, the liquid rises up near the wall. If the radius of the vessel is 5 cm and its rotational speed is 2 rotations per second, then the difference in the heights between the centre and the sides, in cm, will be**

(a) 0.4

(b) 2.0

(c) 0.1

(d) 1.2

**Solution**

The linear speed of the liquid at the sides is rω. So, the difference in height is given as follows

$2gh = \omega^2 r^2$

$h = \omega^2 r^2/2g$

here $\omega = 2\pi f$

Therefore, $h = [(2 \times 2\pi)^2(5 \times 10^{-2})^2]/(2\times10) = 2cm$

**Answer: (b) 2.0**

**Q4: Water is flowing continuously from a tap having an internal diameter $8 \times 10^{-3}$ m. The water velocity as it leaves the tap is 0.4 $ms^{-1}$. The diameter of the water stream at a distance $2 \times 10^{-1}$ m below the tap is close to**

(a) $5.0 \times 10^{-3}$ m

(b) $7.5 \times 10^{-3}$ m

(c) $9.6 \times 10^{-3}$ m

(d) $3.6 \times 10^{-3}$ m

**Solution**

Here, $d_1 = 8 \times 10^{-3}$ m

$v_1 = 0.4$ m $s^{-1}$, h = 0.2 m

According to equation of motion,

$$v_2 = \sqrt{v_1^2 + 2gh} = \sqrt{(0.4)^2 + 2 + 10 \times 0.2}$$

= 2 m $s^{-1}$

According to equation of continuity $a_1v_1 = a_2v_2$

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$(\pi D_1^2/4)\ v_1 = (\pi D_2^2/4)\ v_2$

$D_2^2 = (v_1/v_2)D_1^2$

$D_2 = [\sqrt{(v_1/v_2)}]D_1$

$= [\sqrt{(0.4/2)}]\text{x } 8 \times 10^{-3}$ m

$D_2 = 3.6 \times 10^{-3}$ m

**Answer: (d) $3.6 \times 10^{-3}$ m**

**Q5: A 20 cm long capillary tube is dipped in water. The water rises up to 8 cm. If the entire arrangement is put in a freely falling elevator the length of the water column in the capillary tube will be**

(a) 4 cm

(b) 20 cm

(c) 8 cm

(d) 10 cm

**Solution**

In a freely falling elevator, g = 0 Water will rise to the full length i.e., 20 cm to tube

**Answer: (b) 20 cm**

**Q6: A spherical solid ball of volume V is made of a material of density $\rho_1$. It is falling through a liquid of density $\rho_2$ ($\rho_2 < 1$). Assume that the liquid applies a viscous force on the ball that is proportional to the square of its speed v, i.e., $F_{viscous} = -kv^2$ ($k > 0$). The terminal speed of the ball is**

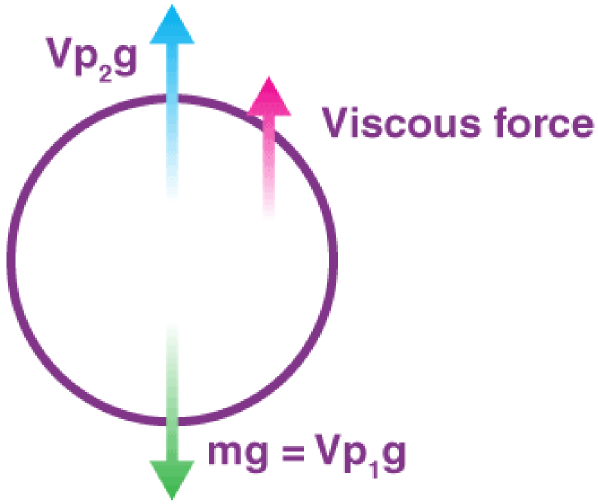
(a) $Vg(\rho_1 - \rho_2)$

(b) $\sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$

(c) $Vg\rho_1/k$

(d) $\sqrt{\frac{Vg\rho_1}{k}}$

**Solution**




The forces acting on the solid ball when it is falling through a liquid is “mg” downwards, thrust by Archimedes principle upwards and the force due to the force of friction also acting upwards. The viscous force rapidly increases with velocity, attaining a maximum when the ball reaches the terminal velocity.

Then the acceleration is zero

$mg - V\rho_2 g - kv_t^2 = ma$ where V is volume,

$v_t$ is the terminal velocity

When the ball is moving with terminal velocity, $a = 0$

Therefore $V\rho_1 g - V\rho_2 g - kv_t^2 = 0$

$v_t = \sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$

**Answer: (b)** $\sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$

**Q7: Water flows into a large tank with a flat bottom at the rate of $10^{-4}$ $m^3s^{-1}$. Water is also leaking out of a hole of area 1 $cm^2$ at its button. If the height of the water in the tank remains steady, then this height is**

(a) 5 cm

(b) 7 cm

(c) 4 cm

(d) 9 cm

**Solution**

Since the height of the water column is constant

Water inflow rate ($Q_{in}$) = Water outflow rate ($Q_{out}$)

$Q_{in} = 10^{-4}$ $m^3s^{-1}$

$Q_{out} = 10^{-4}$ x $\sqrt{(2gh)}$

$10^{-4} = 10^{-4}$ x $\sqrt{20}$ xh

h = (1/20) m = 5 cm

**Answer: (a) 5 cm**

**Q8: A submarine experiences a pressure of 5.05 x$10^6$ Pa at depth of $d_1$ in a sea. When it goes further to a depth of $d_2$, it experiences a pressure of 8.08 x $10^6$ Pa. Then $d_1$ - $d_2$ is approximately (density of water = $10^3$ $ms^{-2}$ and acceleration due to gravity = 10 $ms^{-2}$)**

(a) 300 m

(b) 400 m

(c) 600 m

(d) 500 m

**Solution**

$P_1 = P_0 + \rho g d_1$

$P_2 = P_0 + \rho g d_2$

$\Delta P = P_2 - P_1 = \rho g \Delta d$

$(8.08 \times 10^6 - 5.05 \times 10^6) = 10^3 \times 10 \times \Delta d$

$3.03 \times 10^6 = 10^3 \times 10 \times \Delta d$

$\Delta d = 303$ m $\approx 300$ m

**Answer: (a) 300 m**

**Q9: Water from a pipe is coming at a rate of 100 litres per minute. If the radius of the pipe is 5 cm, the Reynolds number for the flow is of the order (density of water = 1000 kg/$m^3$, coefficient of viscosity of water = 1 mPa s)**

(a)$10^3$

(b) $10^4$

(c)$10^2$

(d) $10^6$

**Solution**

Reynolds number = $\rho vd/\eta$

Volume flow rate = v x $\pi r^2$

$v = (100 \times 10^{-3}/60) \times (1/\pi \times 25 \times 10^{-4})$

$v = (2/3\pi)$ m/s

Reynolds number = $\{(10^3 \times 2 \times 10 \times 10^{-2})/(10^{-3} \times 3\pi)\}$

$\approx 2 \times 10^4$

Order of $10^4$

**Answer : (b) $10^4$**

**Q10: The top of a water tank is open to the air and its water level is maintained. It is giving out 0.74 $m^3$ water per minute through a circular opening of 2 cm radius in its wall. The depth of the centre of the opening from the level of water in the tank is close to**

(a) 6.0 m

(b) 4.8 m

(c)9.6 m

(d) 2.9 m

**Solution**

Here, volumetric flow rate = $(0.74/60) = \pi r^2 v = (\pi \times 4 \times 10^{-4}) \times \sqrt{2gh}$

$\Rightarrow \sqrt{2gh} = [(74 \times 100)/240\pi)]$

$\Rightarrow \sqrt{2gh} = 740/24\pi$

$2gh = (740/24\pi)^2$

$h = [(740 \times 740)/24 \times 24 \times 10)]$ (since $\pi^2 = 10$)

$h \approx 4.8$ m

**Answer: (b) 4.8 m**